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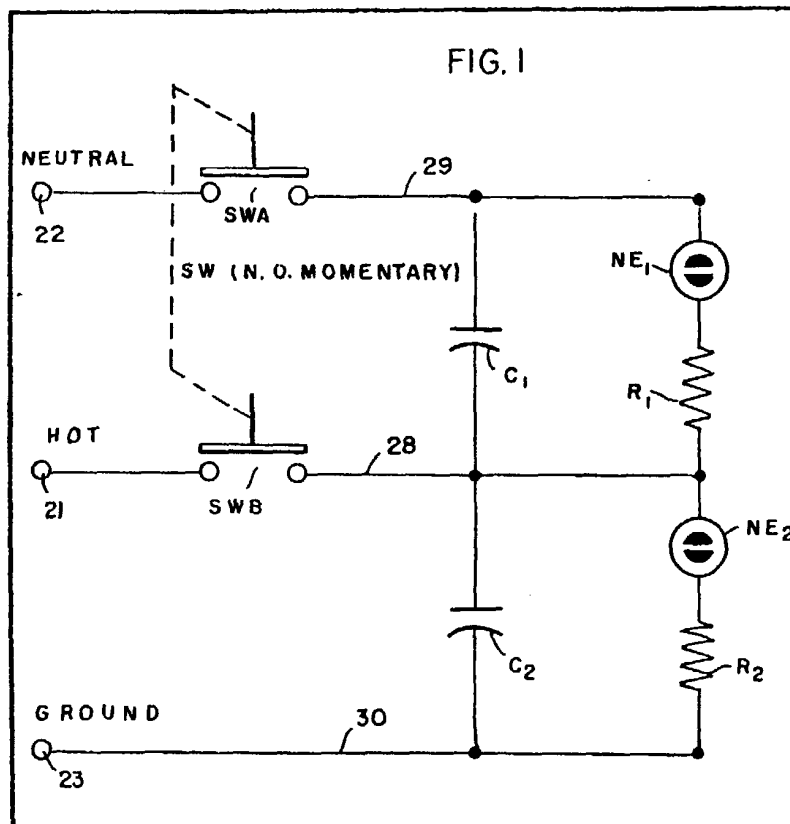
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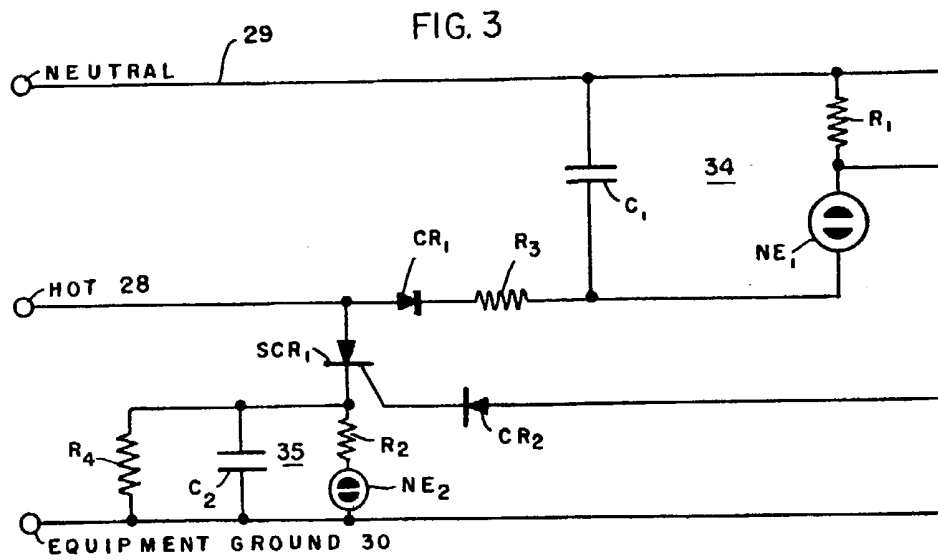
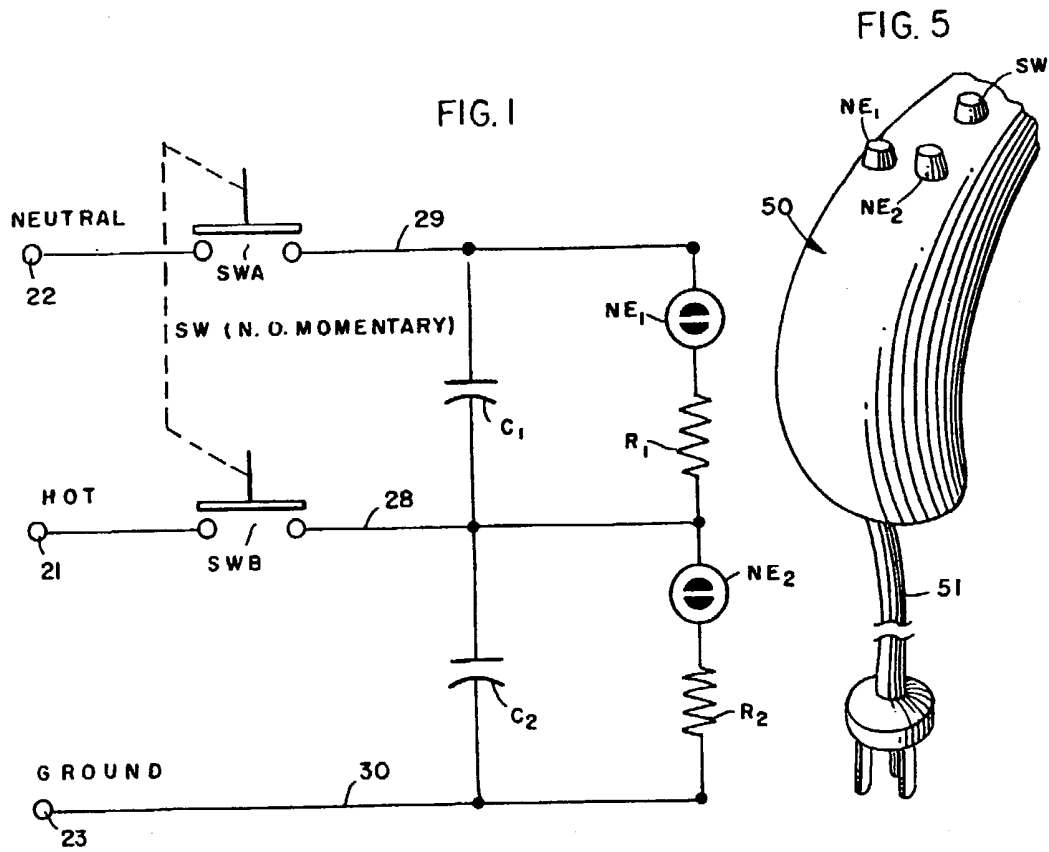
(54) Continuity Testing Circuit for Three-wire Electrical Power Systems

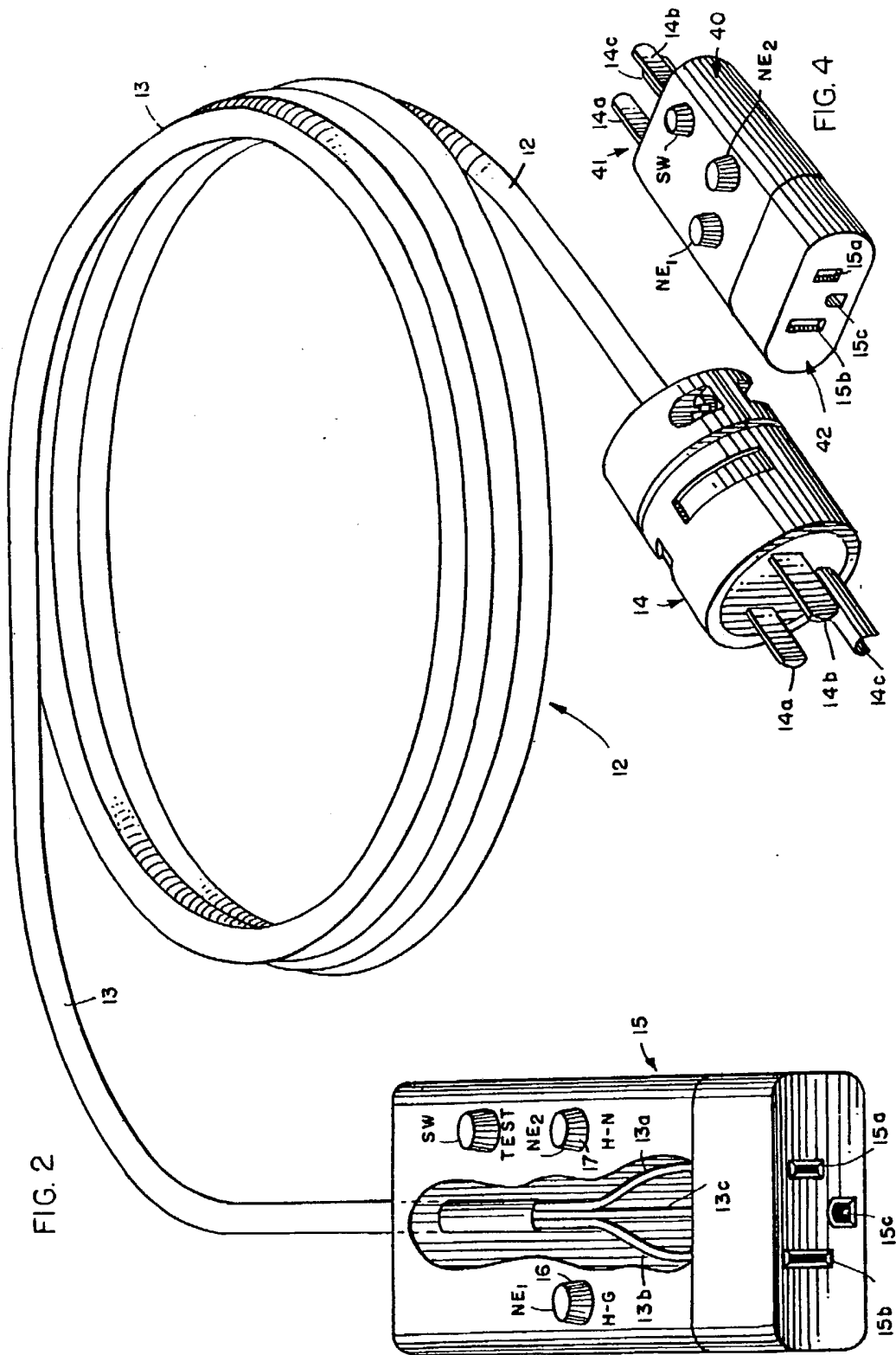
(57) A continuity testing circuit detects and indicates discontinuous ground and wiring reversals in a three-wire electrical power system. The testing circuit includes first and second indicating lamps NE₁, NE₂, and a switch SW manually operable to connect one of the indicating lamps NE₁ between the live and neutral wires of a supply and simultaneously connect the other indicating lamp NE₂ between the live and ground wires. When the switch SW is depressed, if the live and neutral wires are properly connected and if a proper ground connection is established the both lamps are lit, otherwise only lamp NE₁ lights. Capacitive filter circuits C₁, C₂

prevent inadvertant lighting of the lamps due to extraneous RF signals or a ground discontinuity when long lengths of power cord are used. In another embodiment (Figure 3, not shown), the switch includes circuits which periodically connect one lamp between the live and neutral wires and the other lamp between the live and ground wires, providing continuous monitoring of the equipment ground. The indicator lamps are caused to blink on and off if a ground is provided and the live and ground wires are properly connected. The testing circuit may be mounted within an electrical connector provided with a three-pronged plug and three-terminal socket, or within the cord connector of a three-wire cord set, or may be part of an electrical tool.



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SPECIFICATION**Continuity Testing Circuit for Three-wire Electrical Power Systems****Field of the Invention**

5 This invention relates to electrical circuit testing devices, and more particularly to a continuity testing circuit for use with a cord set for detecting and providing an indication of lack of ground continuity, potential ground fault
10 conditions, or improper wiring of three-wire electrical power circuits.

Description of the Prior Art

At the present time, in a large construction program it is a requirement of OSHA that all
15 three-wire electrical power circuits on the construction site be inspected daily and electrically tested on a periodic basis. The daily inspection includes looking for visual defects in the wiring such as damaged or frayed wires,
20 broken plugs or the like. The periodic testing is done at least every three months using a continuity testing device. The testing device detects latent defects, such as discontinuous or defective ground connections as may be caused,
25 for example, by a broken ground wire, an improperly wired plug, or an attempt to defeat the "three-pronged" grounding system by use of a two wire "household" type extension cord as part of the temporary wiring.

30 One such continuity testing device is disclosed in the U.S. Patent 3,383,588 which was issued to R. F. Stoll et al on May 14, 1968. The testing device has a three-pronged polarized plug which enables the device to be plugged into an electrical
35 outlet or the connector of an extension cord. The device has three indicator lamps hard-wired to the terminals of the plug so that each lamp is connected between a different pair of the power conductors. The lamps are selectively lit in
40 response to correct or defective wiring to indicate the wired condition of the outlet, or cord connector, being tested. The test procedure involves unplugging each cord set from its power outlet and inserting the testing device into the
45 outlet. This procedure is time consuming and expensive particularly when there are hundreds or thousands of electrical outlets into which the circuit tester must be plugged to monitor the grounding integrity. Also, since the lamps are
50 hard-wired to the terminals of the plug, the lamps are energized as long as the device remains plugged into an electrical outlet.

A further consideration is that manpower must be allotted to do the testing and in many cases
55 work must be held up both during and in preparation for the testing. Consequently, such testing is generally carried out only as required to meet OSHA standards, and latent defects, such as discontinuous or defective ground connections, may go undetected for as long as three months,
60 or in the case of fixed wires not subject to abuse, as long as six months. Thus, the present safety testing arrangements for electrical wiring do not

achieve as high a level of safety as is desired and also cause down time and misallocation of job site labor.

65 The present invention provides a continuity testing circuit which indicates a discontinuous ground and improper wiring, such as reversal of hot and ground wires in a three-wire electrical power distribution system. The testing circuit includes a pair of indicating lamps, and a switch manually operable to connect one of the lamps between the hot wire and one of the other wires,
70 such as the neutral wire, and the other indicator lamp between the hot and neutral lines. When the switch is operated, and if the hot and ground wires are properly connected, the first lamp lights, and simultaneously, if a proper ground connection
80 is established to the power source, such as a wall outlet, the second lamp lights. Thus, by depressing the switch, the workman can tell at a glance whether or not the grounding is defective and if the power circuit is properly wired, and it is
85 a simple matter for the workman to test the electrical wiring for grounding defects, as well as proper connections, as often as he wishes. Also, the testing circuit is energized only when the switch is operated, thereby normally preventing objectionable current from flowing through the
90 ground wire.

In accordance with a feature of the invention, the testing circuit includes capacitive filter circuits for each indicator lamp. The filter guards against
95 inadvertent lighting of the lamps due to extraneous RF noise. The filter circuits also prevent energization of the lamps under ground discontinuity conditions in application where long lengths of power cord are used.

100 In another embodiment, the continuity test circuit includes switching circuits which periodically connect the lamps between the hot and neutral and the hot and ground lines, respectively, without the need for manual
105 operation of a switch by the workman. This circuit provides "continuous", monitoring of the grounding integrity and immediately warns of obvious and latent grounding defects in the power cord. In normal use, the lamps blink on and off,
110 and should one or both of the lamps remain off, this alerts the worker to the presence of a possible hazard. While the circuit is continuously energized, the disadvantage of power dissipation, albeit small, is offset by the continuous
115 monitoring function provided by the circuit tester.

In accordance with the invention, the testing circuit may be a part of a cord set which extends power from a permanent electrical outlet, such as wall outlet, to the electrical equipment or
120 apparatus being used. The cord set has a plug at one end to be inserted into an electrical outlet, which may be a wall outlet or the connector of an extension cord, and a connector at the other end into which the electrical equipment or apparatus
125 is plugged, the continuity testing circuit being housed within the cord connector and is thus conveniently located near the job site. Also, the circuit tester tests for ground discontinuity or

wiring reversals from the job site back to the power source which may be a wall outlet located far from the job site. The testing circuit may also be mounted within the electrical tool being used, for example, within a hand grip of the tool. In this embodiment, the circuit tests all of the wiring to power source including the power cord for the tool itself and indicates when the housing of the electrical tool is properly grounded.

The testing circuit provided by the present invention is electrically safe and is easy to use and understand by any employee. Also, since each workman can check at any time the power cords associated with the electrical equipment he is using, it avoids down time and hence increases job site productivity as well as assuring the workmen of the safety of the wiring supplying power to the equipment he is using.

Figure 1 is a schematic circuit diagram of one embodiment for a testing circuit, for providing an indication of defective wiring including a ground discontinuity and reversed connections;

Figure 2 is a perspective representation of a cord set having a three pronged plug at one end and a connector at the other which houses the continuity testing circuit provided by the present invention;

Figure 3 is a schematic circuit diagram of a second embodiment for the continuity testing circuit provided by the present invention;

Figure 4 is a perspective view of a continuity testing module provided by the present invention; and,

Figure 5 is a perspective view of a portion of an electrical tool illustrating the continuity testing circuit mounted within the hand grip of the tool.

Referring to the drawings, Figure 1 is a schematic circuit diagram of one embodiment of the continuity testing circuit 10 provided by the present invention for detecting and indicating ground discontinuity and wiring reversals in a three-wire electrical wiring system. In this description, the term "hot wire" refers to the current carrying conductor, the term "neutral wire" refers to the grounded conductor, and the term "ground wire" refers to the equipment ground wire. The neutral and ground wires are connected together at the power supply transformer.

The testing circuit 10 includes a pair of neon lamps NE1 and NE2 and a switch SW manually operable to connect lamp NE2 between the hot and ground wires. When switch SW is operated, and if the hot and neutral wires are properly connected, lamp NE1 is lit. Also, if a proper ground connection is established for the wiring being tested, lamp NE2 is lit.

Referring to Figure 2, the continuity testing circuit includes a three conductor cable 13 terminated at one end with a three-pronged plug 14 and terminated at its other end with a connector 15 which houses the testing circuit 10. The three-conductor cable 13 has a hot wire 13A, a neutral wire 13B and a ground wire 13C which interconnect respective prongs 14A, 14B and

14C of the plug 14 and female terminals 15A, 15B and 15C of the connector 15. The testing circuit 10 has terminals 21, 22 and 23 connected to the hot wire 13A, the neutral wire 13B, and the ground wire 13C, respectively internally in the cord connector 15. The test switch SW is mounted on the top of the cord connector 15 and the indicating lamps NE1 and NE2 are mounted in juxtaposition with apertures 16 and 17 in the upper surface of the connector 15 to be observable externally of the connector 15. Suitable indicia may be provided on the top surface of the cord connector for identifying lamp NE1 as the hot/neutral wire reversal indicator and lamp NE2 as the ground continuity indicator. Alternatively, the lamps NE1 and NE2 may be provided with suitable colored filters to provide distinguishable indications.

The cord set 12 is used to extend power from an electrical outlet to electrical apparatus or equipment, such as a portable power tool or the like, as may be used by a construction worker, for example, at a construction site. Where long runs of wire are required, plug 14 of the power cord set 12 may be plugged into the connector of a three wire extension cord with the electrical device being plugged directly into the connector 15 of the cord set 12.

Referring again to Figure 1, switch SW is a momentary contact, double-pole, single-throw, pushbutton switch having normally open contacts SWA and SWB operable to simultaneously complete a connection between terminal 21, which is connected to the hot conductor 13A, and a conductor 28, and a circuit between terminal 22, which is connected to the neutral conductor 13B, and a conductor 29. Lamp NE1 is connected in series with a current limiting resistor R1 between conductors 28 and 29, and lamp NE2 is connected in series with a current limiting resistor R2 between conductors 28 and 30, which is connected directly to terminal 23 and thus to the ground conductor 13C. When switch SW is operated, contacts SWA connect lamp NE1 between the hot and neutral lines, and simultaneously, the contacts SWB connect lamp NE2 between the hot and ground lines. Thus, when the power cord is connected into a "live" circuit which is wired properly, the lamps NE1 and NE2 will light whenever switch SW is operated.

A capacitor C1 is connected in parallel with lamp NE1 and resistor R1, and a capacitor C2 is connected in parallel with lamp NE2 and resistor R2. The capacitors C1 and C2 provide RF filtering to prevent the lamps NE1 and NE2 from lighting when there is no applied potential. The capacitors C1 and C2 also prevent the lamps from erroneously lighting for a discontinuous ground condition on long wire runs such as when a number of extension cords are used.

Switch SW normally disconnects power from the continuity testing circuit 10 to prevent objectionable current from flowing through the ground wire.

With reference to Figures 1 and 2, in use, plug

14 of the cord set 12 is plugged into a convenient wall outlet, or into the connector of an extension cord which is plugged into such outlet, and the electrical tool being used is plugged into the cord connector 15. Thus, during testing, the entire wire run to the permanent electrical outlet is tested as well as the electrical outlet itself, even where long runs including extension cords are being used.

To test the wiring, the worker depresses the test switch SW to energize the testing circuit 10. Under normal conditions, both lamps NE1 and NE2 will light. Should just indicator lamp NE1 fail to light, this indicates that the hot and ground wires are reversed or that the neutral wire is discontinuous. Should just lamp NE2 fail to light, this indicates that there is a discontinuity in the ground connection for the wiring or that the neutral and hot wires are reversed. Should both lamps NE1 and NE2 fail to light, this indicates that the hot wire is discontinuous or that the hot and neutral wires are reversed and the wire connected to terminal 21 is discontinuous. The lamps are extinguished when the worker releases the switch SW.

Generally, once existing wire has been installed, there may be no need to test for the reversal of the wires if the polarized cord sets are properly used. Thus, a continuity test circuit may be provided which tests only for a ground discontinuity both at the permanent outlet and in the extension cord wiring which extends to the job site. In such circuit, the portion of the continuity testing circuit 10 including indicator lamp NE1, resistor R1 and capacitor C1 may be eliminated, and a single pole switch is used.

Referring to Figure 3, there is shown a schematic circuit diagram of a second embodiment for a continuity testing circuit 10' provided by the present invention. Testing circuit 10' is generally similar to the circuit 10 shown in Figure 1 in that it includes a pair of neon lamps NE1 and NE2 which provide indications for reversal of hot and ground conductors and ground discontinuity. Circuit 10' provides continuous monitoring of equipment ground in that the connection of lamps NE1 and NE2 between the associated pair of the power conductors is effected by way of switching devices including diode CR1 and a silicon controlled rectifier SCR1.

The network 34 comprised of lamp NE1, resistor R1 and capacitor C1, diode CR1 and resistor R3, is connected between the neutral and hot conductors. The network 35 comprised of lamp NE2, resistor R2 and capacitor C2, is connected between the hot conductor 28 and the equipment ground 30 by a switching network 32 including the silicon control rectifier SCR1 and a diode CR2 which is connected between the junction at point 38 of resistor R1 and lamp NE1 and the gate of SCR1. A resistor R4 is connected in parallel with capacitor C2.

When the cord set is plugged into a "live" outlet, diode CR1 is forward biased during each positive half cycle of the AC signal, that is when the hot conductor is positive with respect to the

neutral wire, and is reversed biased during each negative half cycle. Thus, half-wave rectified current is supplied to network 34, charging capacitor C1. After one or two seconds, the voltage across capacitor C1 will exceed the breakdown voltage for lamp NE1, causing the lamp NE1 to light and current flow through the branch including lamp NE1 and resistor R1, establishes a potential at point 38 which is coupled through diode CR2 to the gate of SCR1, causing SCR1 to conduct. When SCR1 conducts, network 35 is connected between the hot and ground conductors causing lamp NE2 to light.

Once capacitor C1 discharges through lamp NE1 and resistor R1, lamp NE1 is extinguished, point 38 returns to ground potential, SCR1 is cutoff and lamp NE2 is extinguished.

The cycle then repeats with switch devices CR1 and SCR1 being operable in the manner indicated above to alternately connect and disconnect power to the networks 34 and 35 including indicating devices NE1 and NE2. The resultant blinking effect of the indicating device draws attention to the condition of the power circuits. Normally the lamps blink on and off. Should either or both of the lamps NE1 or NE2 fail to light, the worker is alerted to the presence of a possible hazard. For example, if the neutral lead is discontinuous, lamps NE1 and NE2 will not blink on and off. If the ground is discontinuous, lamp NE2 will not blink on and off.

Referring to Figure 4, the continuity testing circuits described above as being part of a three-wire cord set may be enclosed within a separate housing 40 provided with a three-prong plug 41 and connector 42. This permits the circuits to be used as accessory units adapted to be plugged directly into a wall outlet or into the connector of a conventional extension cord. Also, as shown in Figure 5, the testing circuits 10 and 10' may be an integral part of an electrical tool or the like, the circuit being mounted, for example, within the pistol grip or handle 50 of such tool. In such application, the continuity testing circuit not only tests the electrical wiring into which the tool is plugged, but also the electrical cord 51 of the tool itself, and indicates when the tool housing is properly grounded. As indicated above, the switch SW is provided only when circuit 10 is used.

Having thus disclosed in detail preferred embodiments of our invention, persons skilled in the art will be able to modify certain of the structure which has been disclosed and to substitute equivalent elements for those which have been illustrated; and it is, therefore, intended that all such modifications and substitutions be covered as they are embraced within the spirit and scope of the appended claims.

Claims

1. In an electrical cord set having hot, neutral and ground wires which terminate at one end in a three-terminal cord connector and at the other end in a three-pronged plug which is adapted to be plugged into an electrical outlet of an electrical

wiring system having hot, neutral and ground conductors for supplying electrical power to said wires of said cord set, the improvement comprising: a continuity testing circuit mounted within said cord connector and having at least one indicating device, switching means operable to connect said indicating device between said hot and ground wires of said cord set, said indicating device being energized upon operation of said switching means to provide an indication when said hot and ground wires of said cord set are connected to said hot and ground conductors, respectively, of said wiring system, and that a ground connection is continuous to an electrical ground of said wiring system.

2. A cord set as set forth in claim 1 wherein said continuity testing circuit comprises a further indicating device connectable between a further pair of said wires, including said neutral wire, under the control of said switching means whereby upon operation of said switching means, said one and said further indicating device are selectively energized as a function of correct or defective wiring of the outlet of said wiring system into which said plug of said cord set is inserted.

3. A cord set as set forth in claim 1 wherein said testing circuit further includes filter circuit means connected in parallel with said indicating device for preventing energization of said indicating device whenever said switching means is unoperated.

4. A cord set as set forth in claim 3 wherein said filter circuit means comprises a capacitor.

5. A cord set forth in claims 1 or 2 wherein said switching means comprises a manually operable switch.

6. A cord set as set forth in claim 2 wherein said switching means comprises a first switching device responsive to AC power signals conducted over said wiring system to periodically connect one of said indicating devices between a pair of wires of said cord set for energization, and a second switching device operable in response to energization of said one indicating device to periodically connect the other one of said indicating devices between a different pair of wires of said cord set.

7. A continuity testing circuit for use in a three-wire electrical wiring system having hot, neutral and ground conductors, for detecting and indicating at least a lack of ground continuity for the electrical wiring system, said continuity testing circuit comprising: at least one indicating device, switching means operable to connect said indicating device between said hot conductor and said ground conductor, and said indicating device being energized upon operation of said switching means, to provide an indication if a ground connection is established between said ground conductor and an electrical ground for said wiring system.

8. A continuity testing circuit as set forth in claim 6 which includes a further indicating device connectable between a pair of said conductors,

including said neutral conductor and another one of said conductors, under the control of said switching means, whereby upon operation of said switching means, said one indicating device and said further indicating device are selectively energized as a function of correct or defective wiring of the electrical wiring system.

9. A continuity testing circuit as set forth in claim 8 which further comprises filter circuit means connected in parallel with said indicating device for preventing energization of said indicating device whenever said switching means is unoperated.

10. A continuity testing circuit as set forth in claim 7 wherein said filter circuit means comprises a capacitor.

11. A continuity testing circuit as set forth in claims 7 or 8 wherein said switching means is a manually operable switch device.

12. A continuity testing circuit as set forth in claim 8 wherein said switching means comprises a first switching device responsive to AC power signals conducted over said wiring system to periodically connect one of said indicating devices between a pair of wires of said cord set for energization, and a second switching device operable in response to energization of said one indicating device to periodically connect the other one of said indicating devices between a different pair of wires of said cord set.

13. A continuity testing circuit as set forth in claim 12 which further comprises resistance means connected in circuit with said one indicating device and energy storage means, said first switching device being periodically enabled by said AC power signals to supply energy to said energy storage means for transfer to said one indicating device to energize said one indicating device, and circuit means responsive to energization of said one indicating device for generating an enabling signal for said second switching device to cause said second switching device to connect the other one of said indicating devices between said different pair of wires of said cord set.

14. A continuity testing circuit as set forth in claim 7 for use with an electrical cord set having hot, neutral and ground wires interconnecting a polarized three-pronged plug and a cord connector, said continuity testing circuit being enclosed within said cord connector of said cord set and having input terminals connected to the hot, neutral and ground wires of said cord set.

15. A continuity testing circuit as set forth in claim 7 for use with an electrical power tool having a three-wire power cord including a ground wire connected to a housing of said tool and hot and neutral wires, said continuity testing circuit being enclosed within said housing of said electrical tool and having input terminals connected to said hot neutral and ground wires of said power cord.

16. A continuity testing circuit as set forth in claim 7 and having a three-terminal connector portion which is mounted in a housing which

encloses said testing circuit, and a three-prong plug portion which is mounted on said housing, said testing circuit having hot, neutral and ground terminals each individually connected to hot,

5 neutral and ground terminals of said connector

portion and said plug portion.

17. A continuity testing circuit substantially as herein described with reference to any of the accompanying drawings.

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